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ABSTRACT

A study was conducted to provide an assessment of the general efficiency of working memory in relation to level of field articulation. The task required a subject to retain a series of digits for subsequent report while performing a semantic modification of a target phrase. The working memory hypothesis predicts that the joint impact of high memory load and semantic complexity will be most detrimental for low field articulation subjects. Extreme scores on Form V of the group Embedded Figures Test was used to select 16 subjects high in field high in field articulation, and 16 subjects low in field articulation. No differences were found between high and low field articulation subjects on either the forward or backward digit-span tests, and there was no difference in the aptness of phrase modifications provided by high and low field articulation subjects. The results of a three-factor repeated measures analysis of variance indicated that there were no significant difference in average response time related either to level of field articulation or to memory load. The semantic task was, however, a significant factor. It was found that under the highest information load, low field articulation subjects recalled fewer digits than high field articulation subjects, made 60 percent more order errors in their recall, and took 38 percent longer to respond with opposite-meaning transformations of target phrases. Implications are discussed. (SW)

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FIELD ARTICULATION AND WORKING MEMORY[1]

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Klein (1954) proposed the term "cognitive style" to designate the trans-situational characteristics of individuals' preferred modes of analyzing, organizing and utilizing information. The most extensively documented trans-situational consistency in cognitive functioning is field articulation and its cognate precursor field independence (cf. Goodenough, 1976). As a theoretical construct field articulation refers to the stable preference for analytic or global processing of information. Analytic processing entails active segmentation of information into relevant parts and interrelations. Global processing is holistic and more passive in character. As an empirical construct field articulation describes performance on tasks which require disembedding and restructuring task information. Proficiency on these tasks is assumed to reflect analytic processing and hence, to designate persons who are "high" in relative field articulation. Conversely, less proficient performance is assumed to reflect a global approach and to indicate persons who are "low" in relative field articulation.

The structuring processes involved in perception, memory, and thought are of central importance in cognition. One of the most valuable contributions of research on cognitive style has been to emphasize the generic role of such processes in all modes of cognition. Further specification of the organization and use of these structuring processes should then enhance our understanding of the functional determinants of cognitive style. Current information-processing models of cognition provide a framework for approaching this problem in more discrete terms. For heuristic purposes let us adopt the view of man as an information-processing system. The various components of an information-processing system represent states (e.g., STM), which have a stable organization and function over time. The particular cognitive operations performed in any state (e.g., rehearsal), are processes which are largely task dependent. Our concern can now be paraphrased as follows: Which states or processes are implicated in the performance differences attributed to cognitive style, in particular to differences in degree of field articulation? The empirical evidence (Witkin, Dyk, Faterson, Goodenough & Karp, 1962; Huteau, 1975; Goodenough, 1976) amply demonstrates that degree of field articulation (or, in many cases, field independence) is correlated with performance across a wide variety of tasks and situations. From the present point of view, this may be taken as implying that some obligatory aspect of information processing is entailed. In other words, some central component of man's information-processing system is mediating cognitive style effects in the tasks studied.

Case (1974), following Pascual-Leone, has proposed that "working memory" is the processing component most directly related to the functional

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differences associated with field independence. As defined by Baddeley and Hitch (1974) working memory (WM) is equivalent to a multipurpose central processing system with limited capacity. The capacity of this subsystem can be used to store information, to perform various cognitive operations, to search long-term memory, and to organize appropriate responses. The proportion of the limited capacity available for any one of these functions is determined by the amount committed to other concurrent activities. When the amount of WM capacity already allocated is high, then any additional activity may exceed the information-handling capability of the system. In that case there may be a delay in responding, hence an increase in task time, or a loss of information, hence an increase in errors.

The relevance of these notions for the explication of field articulation can be demonstrated through an analysis of the embedded figures test (EFT) as an information-processing task. When administered in the conventional format the EFT requires holding some information in mind (the simple figure) while performing other cognitive operations (scanning and analyzing the complex figure), performing tests (comparing the simple figure and portions of the complex figure), and responding (tracing the target in the complex form). Since these activities overlap in time we presume that the limited capacity of WM is rather fully committed while doing the EFT. As Moray (1967) has pointed out, one of the most effective means of coping with a limited capacity system is to develop more efficient processing strategies. It is apparent that different strategies can materially affect performance on the EFT in a number of ways. For example, one strategy would be to identify the most distinctive portion of the simple form and to search the complex form for that feature alone, and only when it has been found to proceed with locating the remainder of the target figure. This strategy minimizes the amount of analysis required, reduces the number of tests required, and takes advantage of the "predictability" of simple forms in locating the remaining features. It epitomizes an analytic approach. Other strategies such as scanning for the whole form, or exhaustive examination of the complex form area by area are less efficient because they produce a greater informational load on WM. From this perspective then, we would expect persons using global strategies to take longer to do the task, or under some conditions to make more errors.

The Case-Pascual-Leone hypothesis can now be restated as follows: when a task requires holding some information in mind while operating on that or other task-related information, persons "high" in field articulation are likely to perform more effectively than persons "low" in field articulation. As we tried to show in our discussion of the EFT, tasks which require disembedding or restructuring maximize these conditions. However, the WM hypothesis implies that other configurations of cognitive acts than the one entailed in disembedding will display cognitive style effects when the joint processing demand approaches the limit of the WM system. If it can be shown that on other tasks which require concurrent information processing, especially one which does not involve the visual modality, that level of performance is associated with degree of field articulation, then the WM hypothesis will have acquired strong empirical support.

This experiment was designed to provide an assessment of the general efficiency of working memory in relation to level of field articulation (FA). The task required a subject to retain a series of digits for subsequent report while preforming a semantic modification of a target phrase. If working memory was a limited capacity then as information load increases operational resources should be at a premium. Taxing those limits should result in either increased time to perform the phrase modification task, or in higher error rates on digit recall, or both. In either instance we would expect to find low FA subjects more adversely affected by high information load than high FA subjects. Information load was varied in two ways, be increasing memory load from 3 to 6 digits, and by increasing the complexity of the semantic processing required for target phrases. In the first case, more WM capacity must be allocated for storage and active rehearsal of the digits. In the second case, more capacity must be allocated for long-term memory search and the cognitive operations entailed in semantic analysis. The WM hypothesis predicts that the joint impact of high memory load and semantic complexity will be most detrimental for low FA subjects.

Method

Subjects

Thirty-two students at the University of Louisville served as subjects in this experiment. They were recruited from a larger group of students who had volunteered to take a battery of tests earlier in the year. Extreme scores on Form V of the group Embedded Figures Test (Jackson, Messick, & Myers, 1964) were used to select 16 subjects high in field articulation, and 16 subjects low in field articulation. The score for this version of the EFT is number of correct tracings out of 16 figures within a time limit of 10 minutes. The average score for the low FA group was 4.56. For the high FA group the mean score was 14.47. The high FA and low FA groups both consisted of 7 males and 9 females. The two groups were comparable in general aptitude: mean ACT verbal scores were 20 for the low FA group and 21 for high FA subjects. Mean ACT quantitative scores were 22 and 24 for low FA and high FA groups respectively.

All subjects were paid for their participation.

Design

A three-factor design consisting of two between-subjects variables (memory load and level of field articulation) and one within-subject variable (semantic task) was employed. Within level of FA, subjects were randomly assigned to memory load conditions.

Materials

Common similes (e.g., "wise as an owl") were used for the semantic task. These were selected from the Similes Preference Inventory developed by Pearson and Maddi (1966). Only the versions designated by Pearson and

Meddi as the usual, or conventional expression were used. Of the 54 phrases, six were used as practice items and 48 comprised the set of targets presented in the experiment. The phrases were grouped into 8 blocks of 6 with random assignment to blocks and positions within blocks. Digit sequences were chosen from a random number table with the following constraints: (a) the sequence contained no more than two occurrences of a single digit (b) no strings of three or more digits in either a forward or reverse sequence were permitted (e.g., 701239; 703219). The three-digit sequences consisted of the first three digits of the six-digit sequences.

Procedure

Before the experimental session proceeded the forward and backward digit span test of the WAIS was administered to each subject. Instructions were then given to the subject explaining the two tasks to be performed. These instructions emphasized that retention of the digits while modifying a phrase would be difficult and required concentration and care. Regarding the digits they were informed that the numbers must be reproduced in the original (or presentation) order to be counted correct. The two forms of phrase modification which would be required were then detailed. A phrase was either to be converted into one which would express a meaning opposite to the original, or to be modified in a way which expressed a synonymous meaning. In either case only the final word of the simile was to be changed. The substitution, however, had to affect the meaning of the phrase as a whole. Thus, the subject was to choose a substitute word that either preserved the figurative meaning of the original, or altered the entire phrase so that its meaning would be contrary to that of the original phrase.

Half the phrases were to be modified in a synonymous manner and half in a contrary manner. The requirement was announced by the experimenter before beginning each successive set of phrases and applied to the entire block of similes. The sequence of "opposite" or "same" instructions was counterbalanced between the first 4 and the last 4 blocks. Both the digit series and the phrases were presented visually using a Stowe memory drum.

The sequence of task events was as follows: The word "ready" appeared in the aperture of the memory drum and was followed by a digit series. The digits were exposed for two seconds. The drum was advanced with a blank field for another two seconds during which time the subject had been instructed to actively rehearse the digits. Then the phrase was shown and remained in view until the subject recited out loud the modified version of the phrase. The interval from presentation to response was timed by the experimenter with a stopwatch and recorded. Immediately after reciting the modified phrase, the subject wrote the digit series on a response form. Subjects practiced this cycle with six phrases after which the 48 test items were administered.

Results

WAIS digit span

There were no differences between high FA and low FA subjects on either the forward or backward digit-span tests. The mean number of digits correct were (a) on forward series, 6.9 for high FA subjects and 6.5 for low FA subjects; (b) on backward series, 4.7 for high FA subjects and 4.8 for low FA subjects.

Response Appropriateness

The character of the phrases used precluded identifying any simple substitute term as the "correct" one. Both experimenters examined the complete set of substitutions and judged their appropriateness. For high FA subjects, 1.8% of the responses were judged to be inappropriate in the 3-digit condition and 2.6% were so judged in the 6-digit condition. For low FA subjects in the 3-digit condition only 1.8% of the substitutions were regarded as inappropriate, but in the 6-digit condition 8.5 % were considered unacceptable. In virtually all instances, however, the inappropriateness was the result of complying with the noncurrent instruction, i.e., converting phrases to similar meanings when instructed to obvert their meaning, and conversely. However, none of the inappropriate substitutions were deleted from the time or error analyses thus providing a somewhat more conservative test of the expected differences between high and low FA groups.

The substitutions showed remarkable agreement across groups both as regards the most common choice of substitute term, and the variety of specific words used. There was then, no difference in the aptness of phrase modifications provided by high and low FA subjects.

Response Time

The time required to produce modified phrases showed no trend within or across blocks of items in any of the four groups of subjects. Therefore two summary time scores were calculated for each subject: the average time required for the 24 "same meaning" phrases, and the average time required for the 24 "opposite meaning" phrases. Mean time scores for each condition are shown in Table 1.

The results of a three-factor repeated measures analysis of variance indicated that there were no significant differences in average response time related either to level of field articulation or to memory load. The semantic task was however, a significant factor, $F(1,28) = 15.06$, $p < .001$. The increase in average response time for "opposite meaning" phrases was small but highly consistent. Supplementary t-tests confirmed that the increase was significant in all groups except the 6-digit, high FA condition. All tests were one-tailed, and $p < .02$ in each case. The increase in response time was proportionately greater for low FA subjects in the 6-digit condition than in any other condition. The three-way interaction of articulation, semantic task, and memory load was highly

significant, F (1,28) = 6.94, $p < .02$. The articulation x semantic task interaction was marginally significant ($p < .10$), but the memory load x semantic task, and the memory load x articulation interactions were negligible.

Digit Recall

Each of the 48 digit sequences was scored for both unordered and ordered recall. In the former case digits which were in the presented series were counted as correct regardless of position in the recalled series. In the latter case strict preservation of serial order was required to be counted as correct. The results of these tabulations are summarized in Table 2. There was no difference between high FA and low FA groups in the 3-digit condition in unordered recall. There was a small but significant difference favoring high FA subjects in unordered recall of 6-digit sequences, $t(7) = 1.88$, $p < .05$ (one-tailed). In scoring recall for order accuracy two kinds of errors were identified-transposition of digits within the sequence, and substitution of new digits for presented ones. Order was strictly defined in relation to presentation position. Thus, contiguity produced by simple omission of a digit in recall did not count as an order error. Similarly, instances where no digits were recalled at all were not counted in this analysis.

The results of a three-factor repeated measures analysis of variance on total order errors per subject indicated that the main effect of articulation was significant, $F(1,28) = 5.39$, $p < .05$, as was the main effect of memory load, $F(1,28) = 52.17$, $p < .001$. There was no difference in error frequency as a function of semantic task. None of the interactions were significant. The effect of memory load was to be expected and has little bearing on the main concern of this investigation. The relationship of errors to level of articulation is directly relevant. As can be seen from Table 2, low FA subjects averaged 60% more order errors in recall of 6-digit sequences than high FA subjects. The difference between high and low FA groups in the 3-digit condition was not significant.

Analysis of errors in relation to digit position indicated further interesting differences among high and low FA subjects in the 6-digit condition. These data are shown in Figure 1. High FA subjects made fewer order errors overall, but with nearly equal frequency at each digit position. Low FA subjects made more order errors overall, and the number increased across digit positions in a manner resembling the traditional serial position error curve. A repeated measures analysis of variance of these data indicated that the interaction of level of articulation and serial position was highly significant, $F(5,70) = 6.76$, $p < .01$. There were no comparable differences in error patterns in the 3-digit conditions.

Hunt, Lunneborg, and Lewis (1975) reported that college students with high verbal aptitude retained order information in short-term memory better than those of average aptitude. In order to determine whether differences in aptitude were confounding the error data reported above correlations between ACT scores, EFT scores, and total order errors were computed. The product-moment correlations between ACT-Verbal and total order errors were

-.23 for the 3-digit groups and .13 for the 6-digit groups. Correlations with ACT-Math score were .14 and -.17 respectively. The point-biserial correlations between ACT-Verbal, ACT-Math and field articulation scores were .08 and .16 respectively. None of these correlations are statistically significant. Thus, there was no evidence that aptitude differences were contributing to the results obtained in this experiment.

Discussion

This experiment assessed the proposal that performance differences associated with field independence/field articulation reflect differential efficiency in the use of a limited capacity information-processing system termed working memory. We assumed that such differences would be most evident in high information-load conditions and the results confirmed this expectation. The combination of two levels of memory load and two degrees of complexity in semantic processing may be viewed as defining a dimension of information load which has three levels. These are specified in Table 3. Under the highest information load low FA subjects recalled fewer digits than high FA subjects, made 60% more order errors in their recall, and took 38% longer to respond with opposite-meaning transformations of target phrases. It might be argued that the results imply differences in absolute processing capacity and not just differences in processing efficiency. But, if that were true we would expect to find differences in performance at all levels of information load and that was not the case. At the lowest level high and low FA groups were equivalent, and at the intermediate level both groups showed evidence of accommodating to the increment by increased response time (high FA: 3-digit/opposite meaning items) or increased errors (low FA: 6-digit/same meaning items).

Two aspects of the results provide a more concrete illustration of the concept of capacity vis-a-vis efficiency. First, no differences were found between high and low FA subjects on the WAIS digit span tests. This is consistent with previous research on cognitive style and rote memory (Goodenough, 1976). Thus, it is likely that recall errors on task series were not due to failure to store the information and that storage capacity per se does not differ among the contrasting groups. The serial position error data strongly imply that low FA subjects were not able to muster sufficient resources to maintain adequate rehearsal of the full 6-digit series. Active rehearsal clearly requires processing capacity (cf. Kerr, 1973), and retention of order information is particularly demanding. For low FA subjects this requirement may have been the straw that broke the camel's back. A qualitative feature of the data is pertinent in this regard, viz., the fact that in the 6-digit condition low FA subjects failed to comply with the current phrase-modification instruction much more often than any other group. Remembering task instructions requires WM capacity too.

Cognitive style effects are often interpreted in terms of stable differences in preferred cognitive strategies. Some may doubt whether the present study has accomplished anything beyond documenting another case where strategy differences can affect performance. Unfortunately, we have no indications in our data as to what strategies the subjects used. However, the import of the WM hypothesis is that strategy differ-

ences may amplify the contribution of a component of the intrinsic information-processing system common to everyone. That is, strategies are not the only substantive factor in cognition. Other features of our capability for handling information impose significant constraints as well. It may be true that low FA individuals prefer global or holistic modes of processing, but one effect of that preference is to functionally diminish the available processing capacity of WM.

The information-processing approach developed in this paper is also consistent with the results of DeFazio's (1973) study of field articulation and language processing. DeFazio found that high FA subjects shadowed sentences varying in grammatical and semantic acceptability much better than low FA subjects. He proposed that high FA individuals have developed more differentiated representations of the sequential structure of language and that this facilitated the analytic processes involved in speech perception. Since speech comprehension appears to require brief retention of a few preceding words while current items are assessed for meaning and structural clues, as well as an ongoing integration of information, it is reasonable to suppose that WM is centrally involved in this activity (cf. Hung, 1971).

In summary, we believe that information-processing paradigms can contribute significant insights into the functional determinants of cognitive style. The dynamics of working memory are obviously not the only factor involved in perception, memory, and thought. However, a closer examination of the interactions of other cognitive states and processing strategies could lead to a fuller explication of such individual difference dimensions as field articulation.

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Table 1

Summary of response time scores (seconds)

Memory Load	Semantic Task	Field Articulation			
		High		Low	
		X	SD	X	SD
3 digits	Same	6.66	2.53	7.13	2.19
	Opposite	7.91	2.78	7.92	2.00
6 digits	Same	7.75	2.01	7.64	2.51
	Opposite	7.78	2.86	10.71	4.88

Table 2

Summary of error frequency in digit recall

Memory Load	Subjects	Digits per string correct (unordered)		Total transposition/ substitution errors	
		X	SD	X	SD
3 digits	High FA	2.88	0.08	8.25	4.11
	Low FA	2.82	0.19	12.12	10.67
6 digits	High FA	5.37	0.44	50.50	23.44
	Low FA	4.88	0.61	83.00	32.19

Table 3

Summary of results as a function of information load and level of field articulation

Information Load		Response Measure: Recall Errors	Response Time
Low:	3 digits/same meaning	High FA = Low FA	High FA = Low FA
Intermediate:	3 digits/opposite meaning	High FA = Low FA	High FA > Low FA
	or		↓↑
	6 digits/same meaning	High FA < Low FA	High FA = Low FA
High:	6 digits/opposite meaning	High FA < Low FA	High FA < Low FA

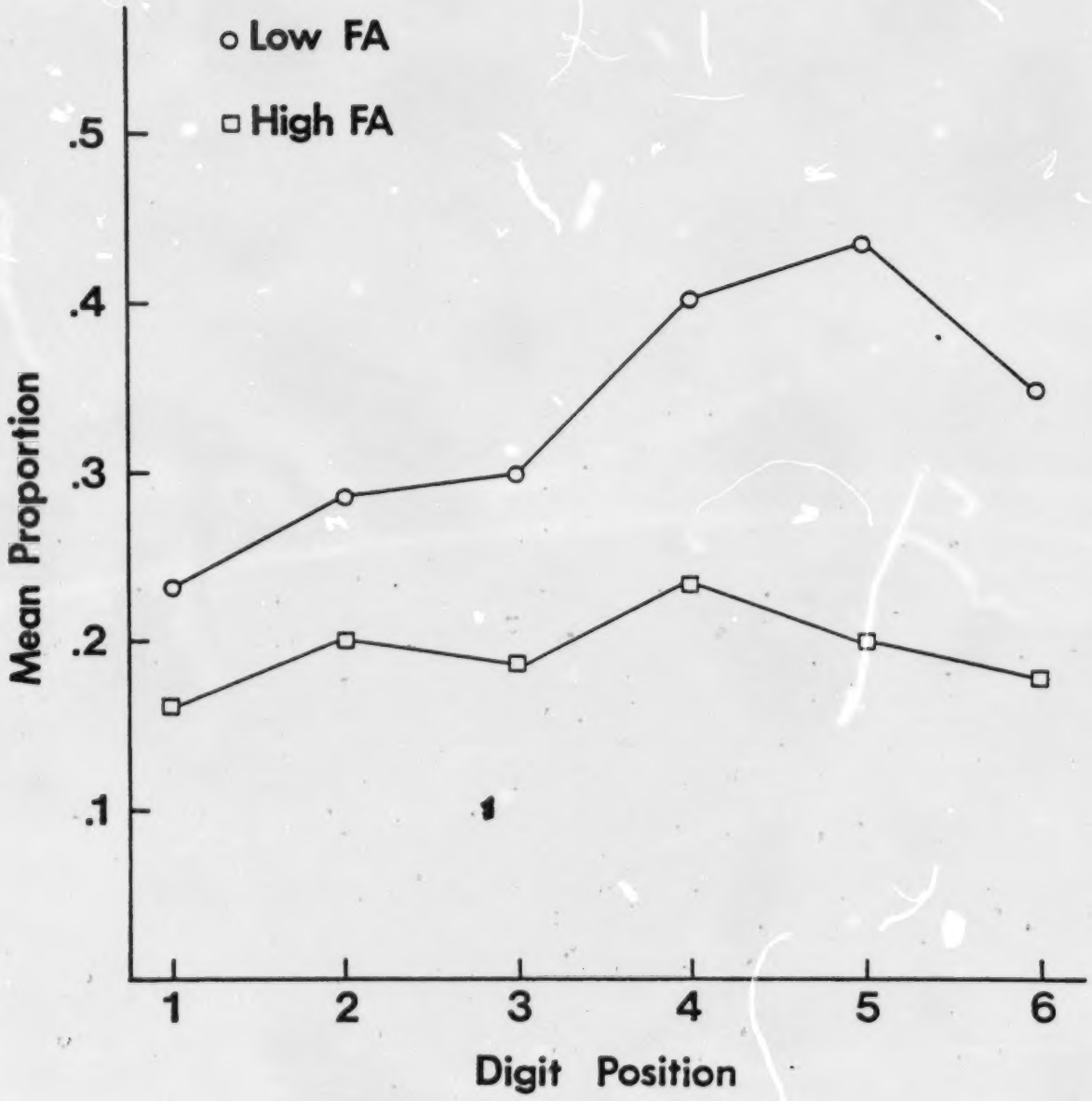

Figure 1. Mean proportion of errors in relation to digit position and field articulation.